Physical, social and institutional vulnerability assessment in small Alpine communities. Results of the SAMCO-ANR project in the Upper Guil Valley (French Southern Alps)

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1- Background

The **Guil catchment** is particularly **prone to torrential and gravitational hazards** such as floods, debris flows, landslides or avalanches due to several predisposing factors (bedrock supplying abundant debris, strong hillslope-channel connectivity) in a context of summer Mediterranean rainstorms as triggers. Since the second half of the 20th century, the progressive decline of agropastoralism and the development of tourism activities led to a concentration of human stakes on alluvial cones and valley bottom, therefore an increase of vulnerability for mountainous communities. Following the **1957 and 2000 catastrophic floods** and the **1948 and 2008 avalanche episodes**, some measures were taken to reduce exposure to risks (engineering works, standards of construction, rescue training...). Nevertheless, in front of urban expansion (land pressures and political pressures) and obsolescence of the existing protective measures, it is essential to reassess the vulnerability of the stakes exposed to hazards. In the frame of the **SAMCO project** designed for mountain **risk assessment in a context of global change**, we developed a systemic approach to assess three specific components of **vulnerability** – **physical, social and institutional** – for the six municipalities of the Upper Guil catchment: Ristolas, Abriès, Aiguilles, Château-Ville-Vieille, Molines-en-Queyras and St-Véran (Fig. 1).

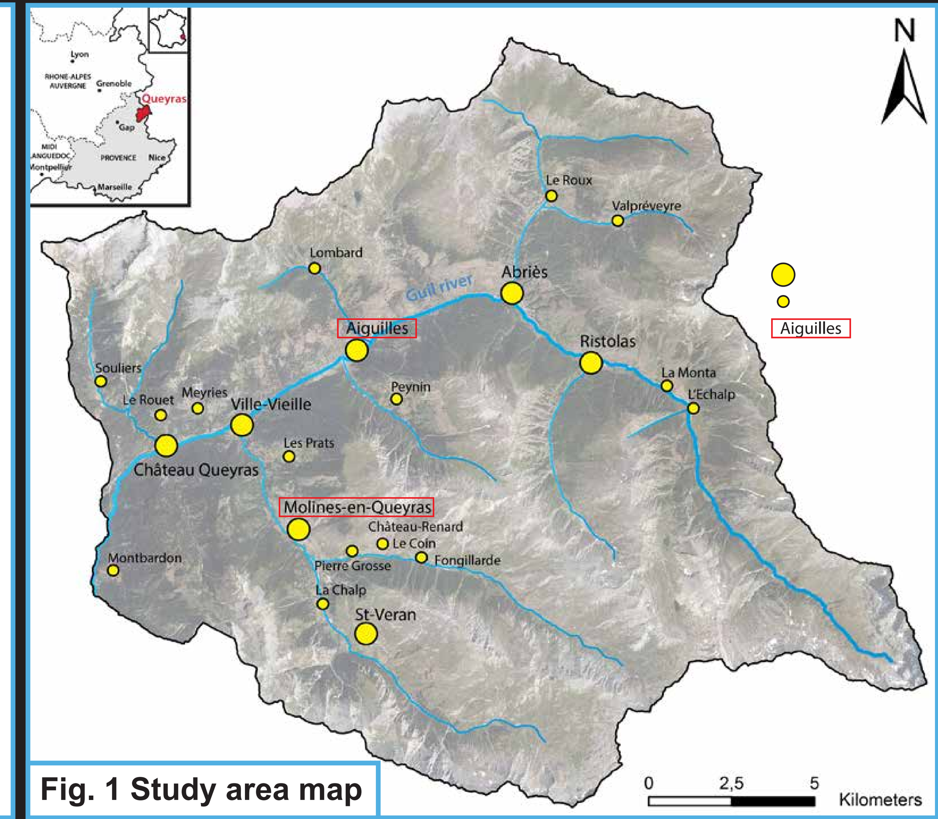


Fig. 1 Study area map

2- Methods

Physical vulnerability (i.e. total potential consequences of hazards on stakes) was estimated and mapped via **GIS model** from **Potential Damage Index** (PDI) (Fig. 2). This index allowed us to quantify and describe both **direct - physical injury, structural and functional impacts - and indirect consequences - socio-economic impacts** - induced by hazards; this by combining weighted parameters reflecting the exposure of elements at risk: **buildings, network and land cover** (Fig. 3). At least 1890 buildings, 367 km² of land cover and 902 km of network were considered. Vulnerability maps were **then crossed to hazard map** reflecting different scenarios of exposure. To take into account the temporal variability of vulnerability, we produced **different maps for summer and winter periods**.
To assess **social and institutional vulnerability** we realized **questionnaires** (5% of the total population investigated), **interviews** and **mind-maps** (80 collected) dealing with risk perception, mitigation measures and confidence in the actors of risk management.

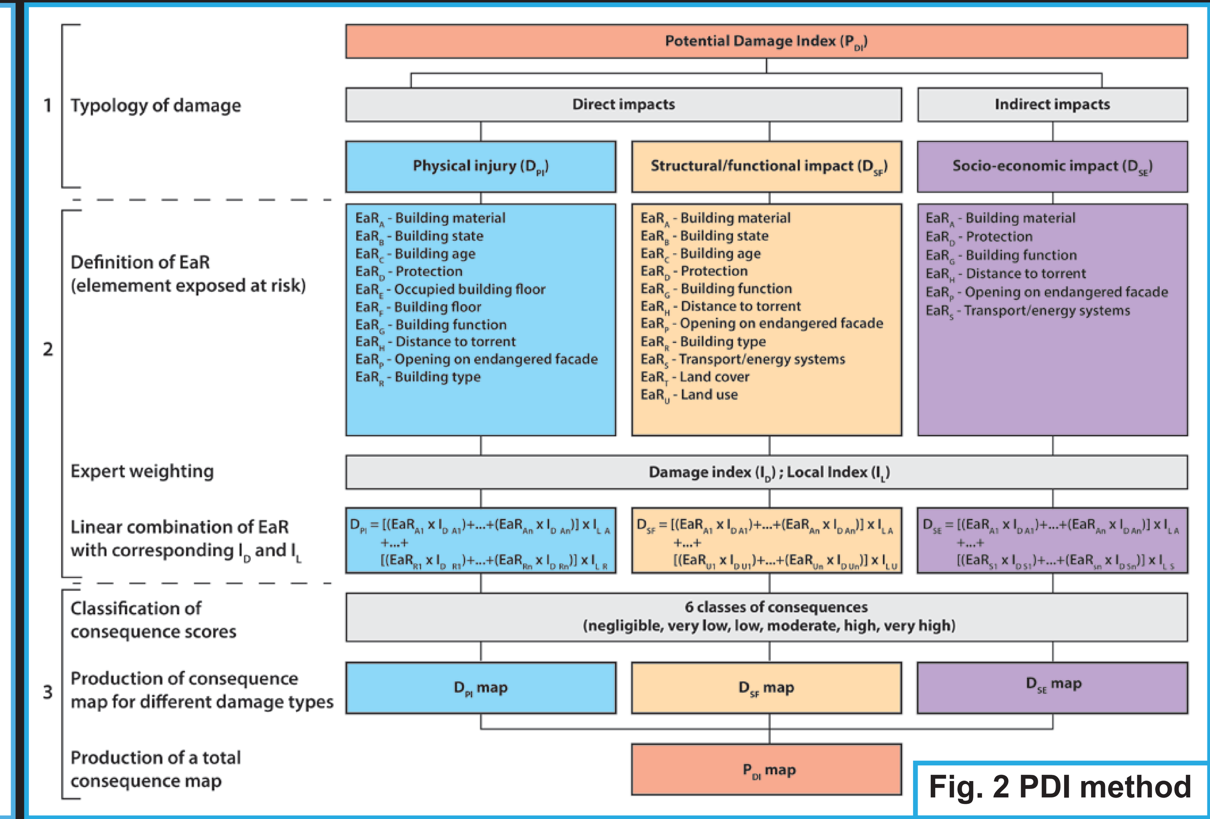


Fig. 2 PDI method

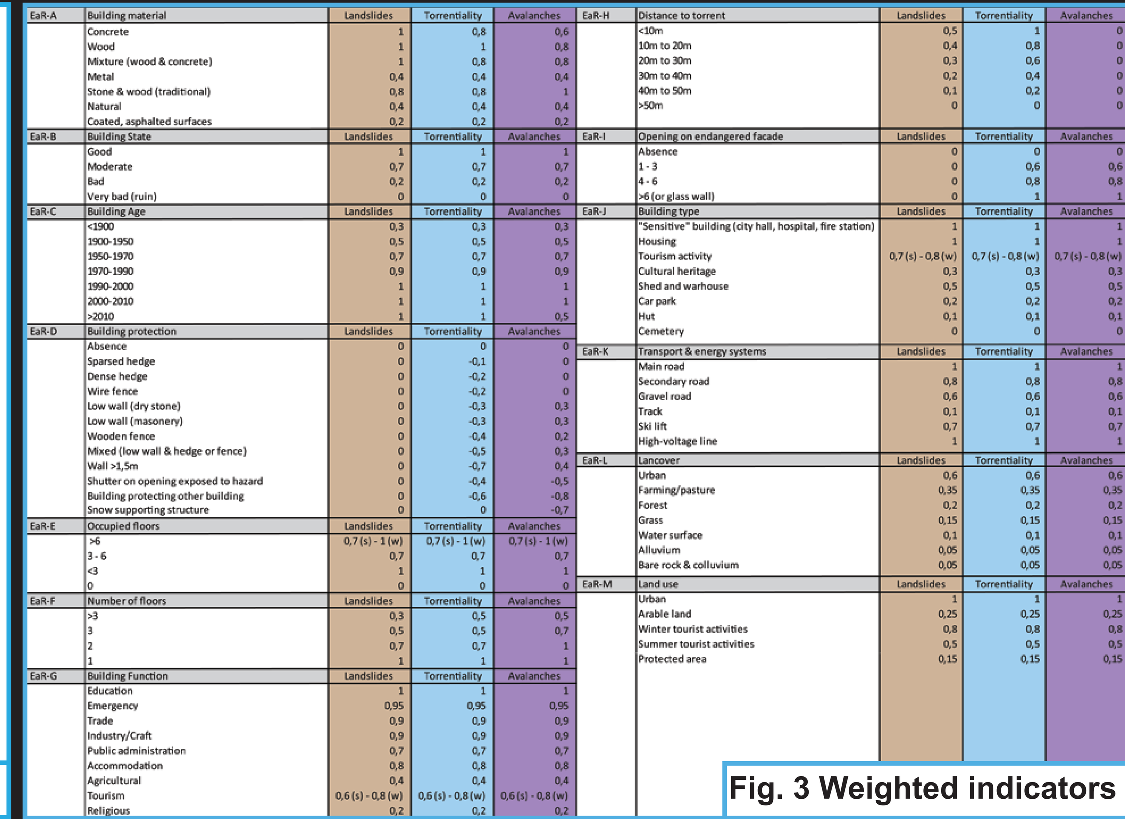
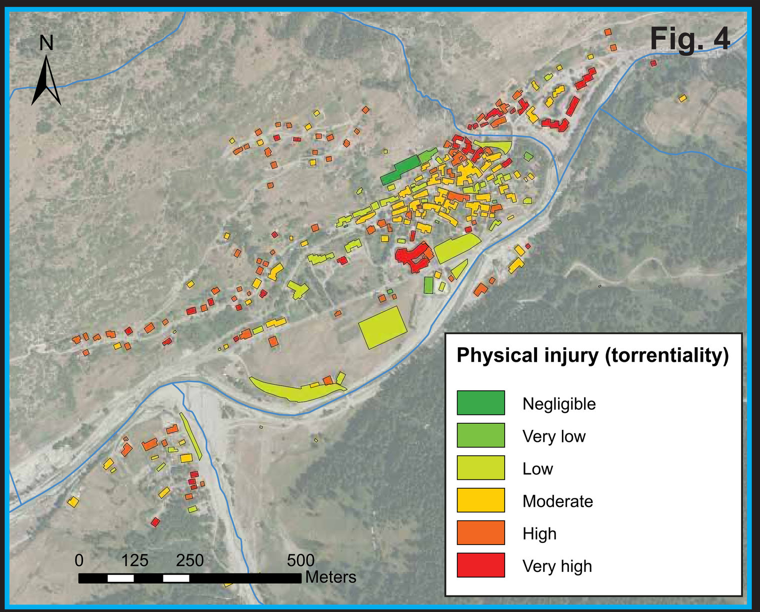
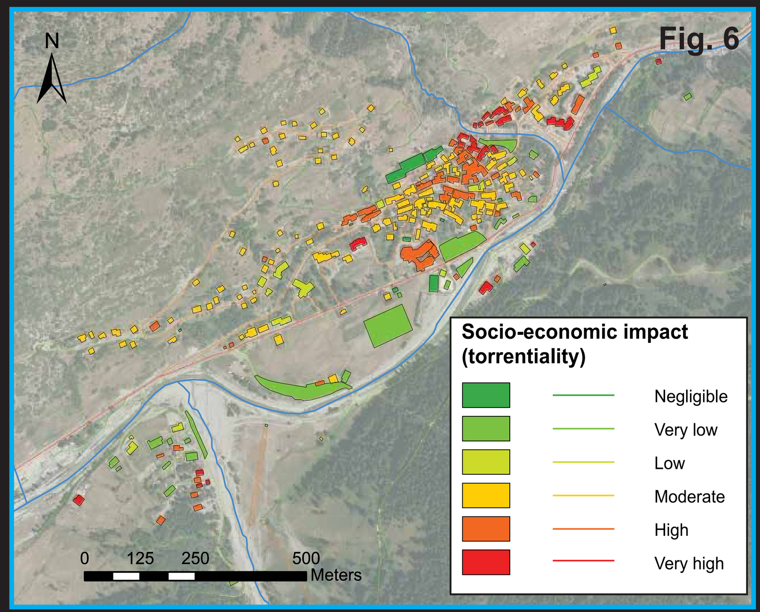
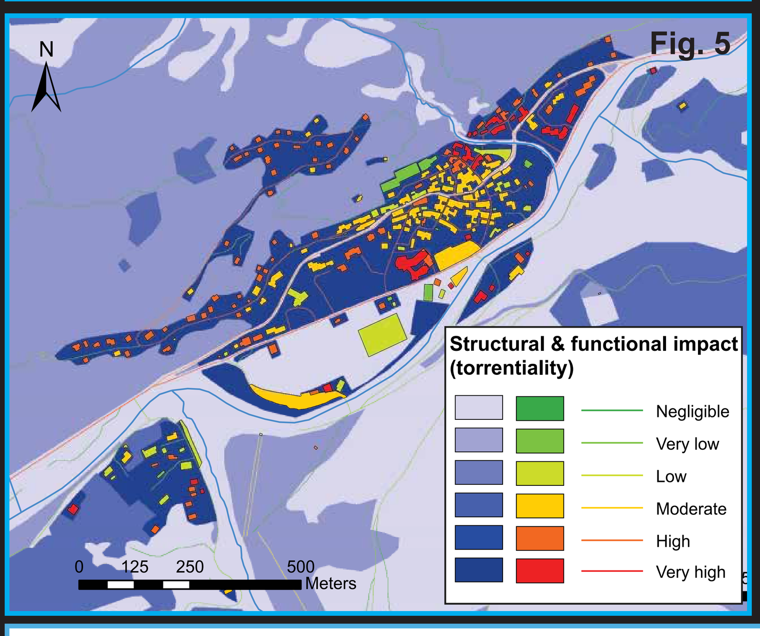


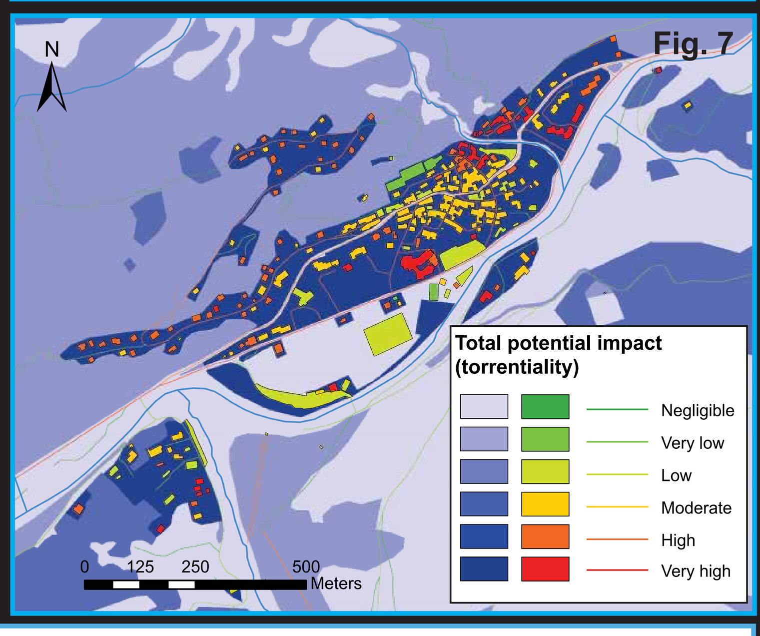
Fig. 3 Weighted indicators

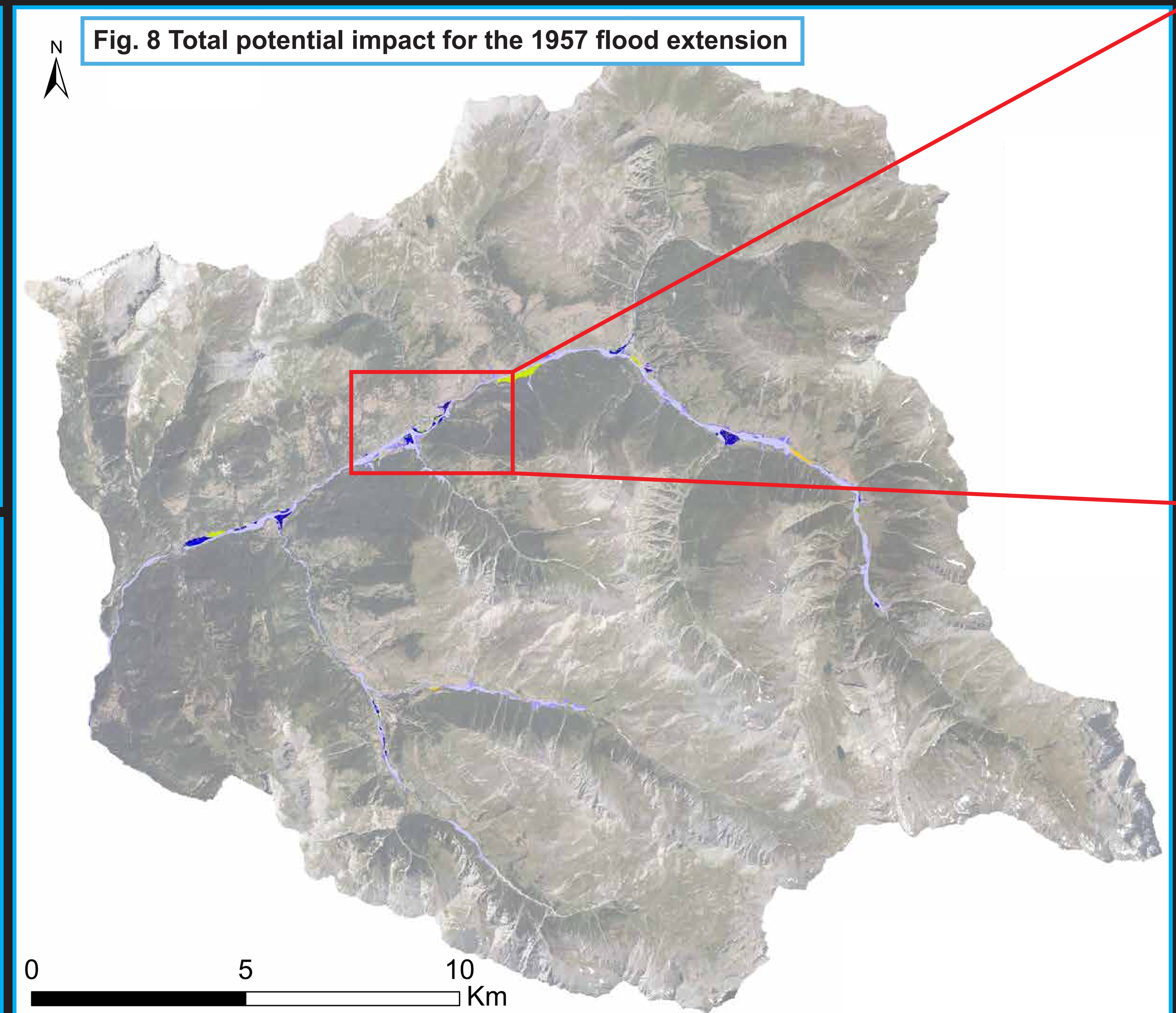
3- Results : physical vulnerability assessement

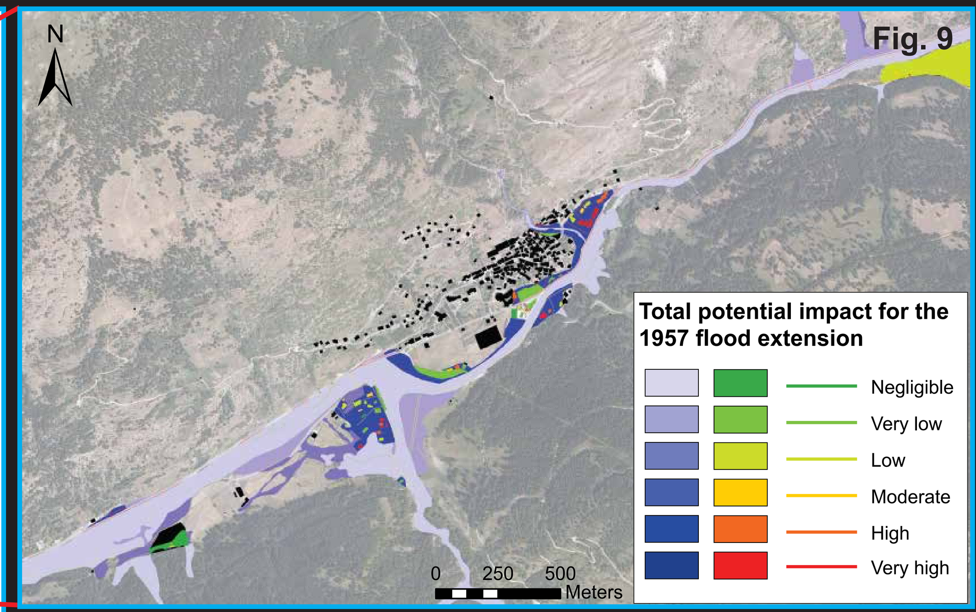


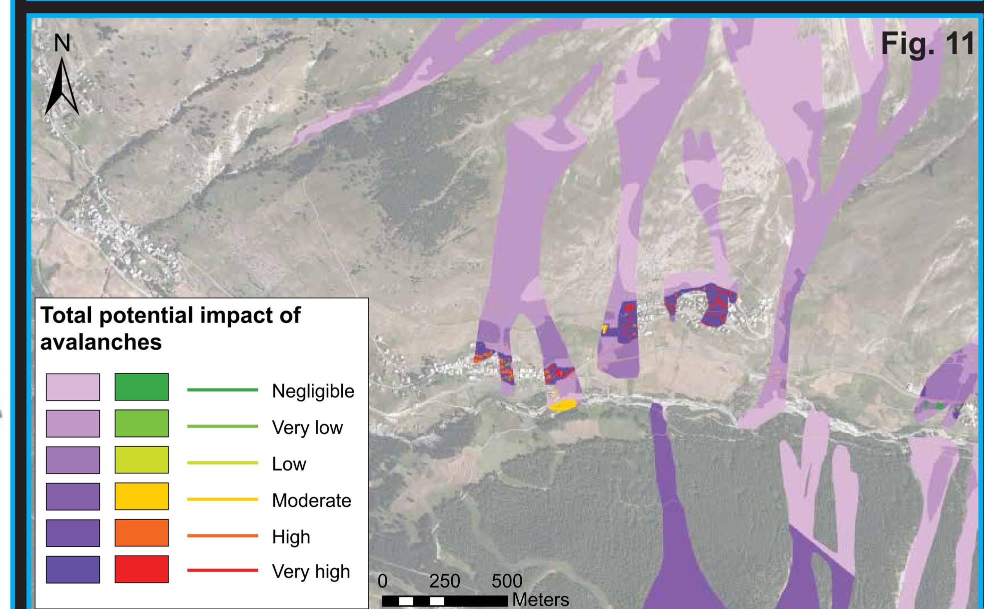


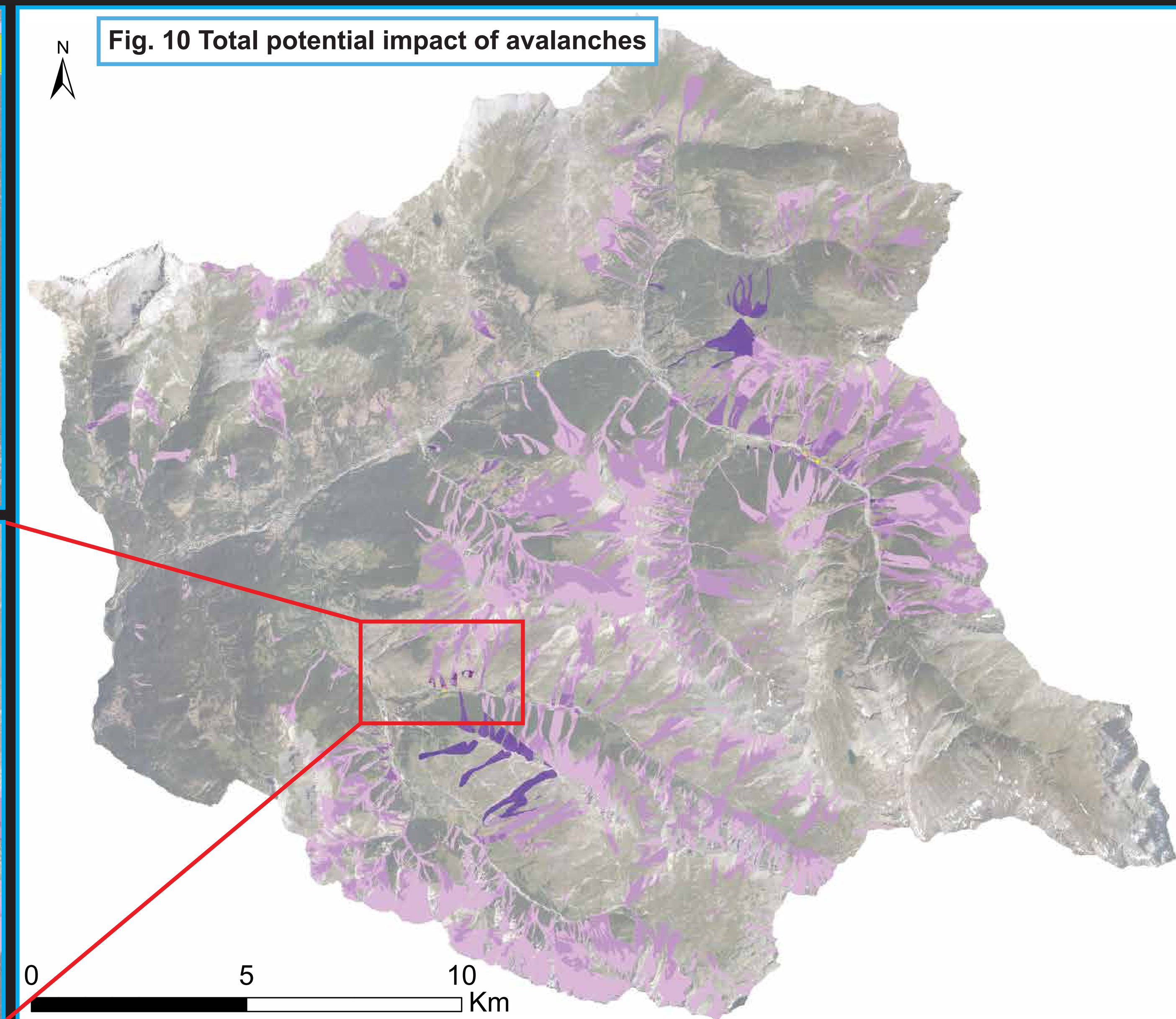












For the sake of clarity for readers we present here only few scenarios: summer torrential vulnerability, summer torrential risk for 1957 flood extension and winter avalanche risk. The highest degree of potential **physical injury** (Fig. 4) for flooding is preferentially located in **recent settlement on the outskirts of historical villages** which are often close to torrential rivers. **Potential structural and functional vulnerability** map for flooding (Fig. 5) put forward **urbanized and cultural space**.

Potential structural and functional vulnerability map for flooding (Fig. 5) put forward **urbanized and cultural space**. Regarding building, we observe a high degree of vulnerability on **recent housing, store and public services**. Concerning networks, the **major roads (D947)** appear to be vulnerable on many points and particularly **near torrential confluence areas. Socio-economic maps** (Fig. 6) bring to light **touristic issues** such as shops, camping grounds and lifts.

As expected, **total potential vulnerability** for flooding (Fig. 7) is highest for **public services, recent housing and networks** close to the Guil River and its main tributaries. Combined with the **Ri>100 year 1957** flood extension, we observed that more than **411 ha** of land and **289 buildings** could be endangered.

Especially in the 4 villages of the main valley: Ristolas, Abriès, Aiguilles and Château Queyras (Fig. 8 and 9). Considering **winter risk for avalanches**, we count about **665 ha** of land and **127 buildings** potentially impacted, these occuring mostly in the upper part of Guil catchment in **Ristolas** municipality and in the adjacent valley of Aigues in the municipalities of **Molines-en-Queyras** and **St-Véran** (Figs. 10 and 11).

4- Results : Social and institutional vulnerability assessement

Questionnaires and interviews suggest that Queyras inhabitants are **globally aware and well informed** about risk in their municipality (Fig. 12 and 13). According to their response, floods and avalanches are the major risks to consider. Many of them (Fig. 14) have experienced a natural disaster, which suggest a **good memory** of risk. Mind-maps (Figs. 16 and 17) lead in that direction. Nevertheless, just few of them considered that they could be directly and physically affected by risk (Fig. 13); and there is still **7%** of people which are **not informed about risk**. These are often **seasonal workers or newcomers** such as retired people. Regarding to confidence towards stakeholder we observe a clear **preference for local authorities** and civil security which are the most visible actors in those isolated regions (Fig. 15).

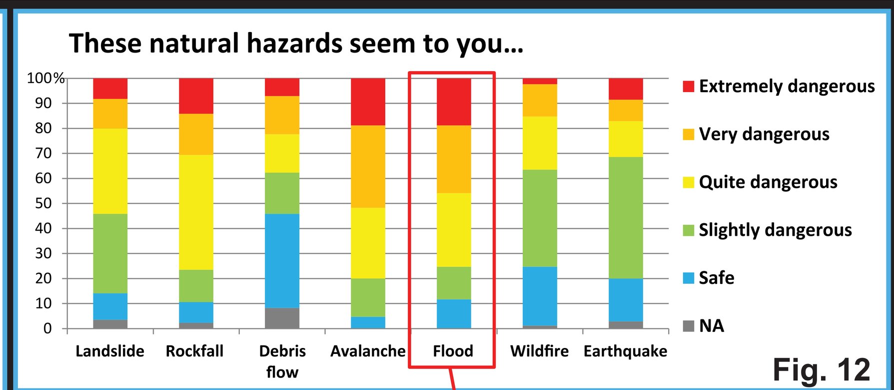


Fig. 12

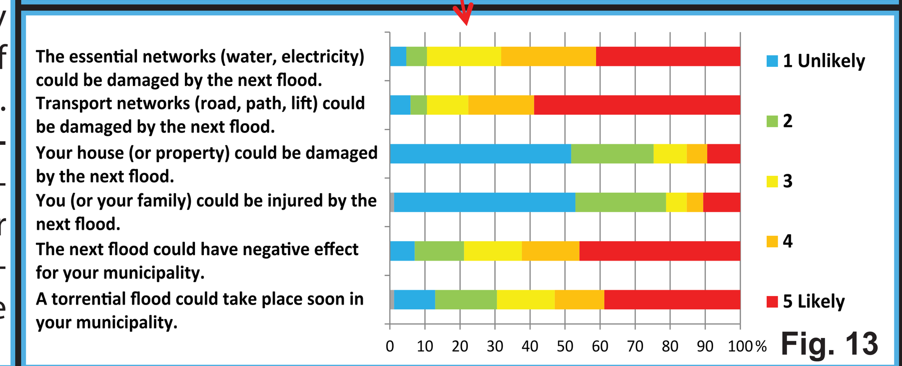
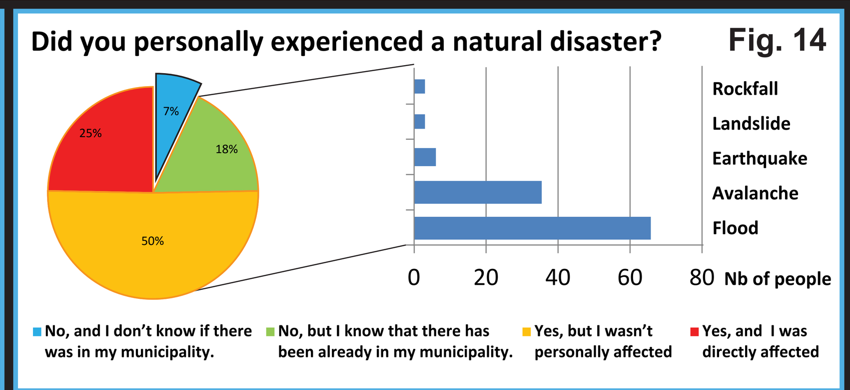


Fig. 13



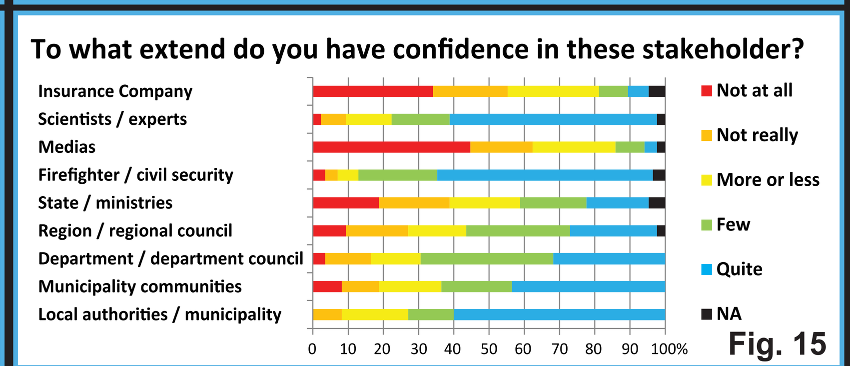
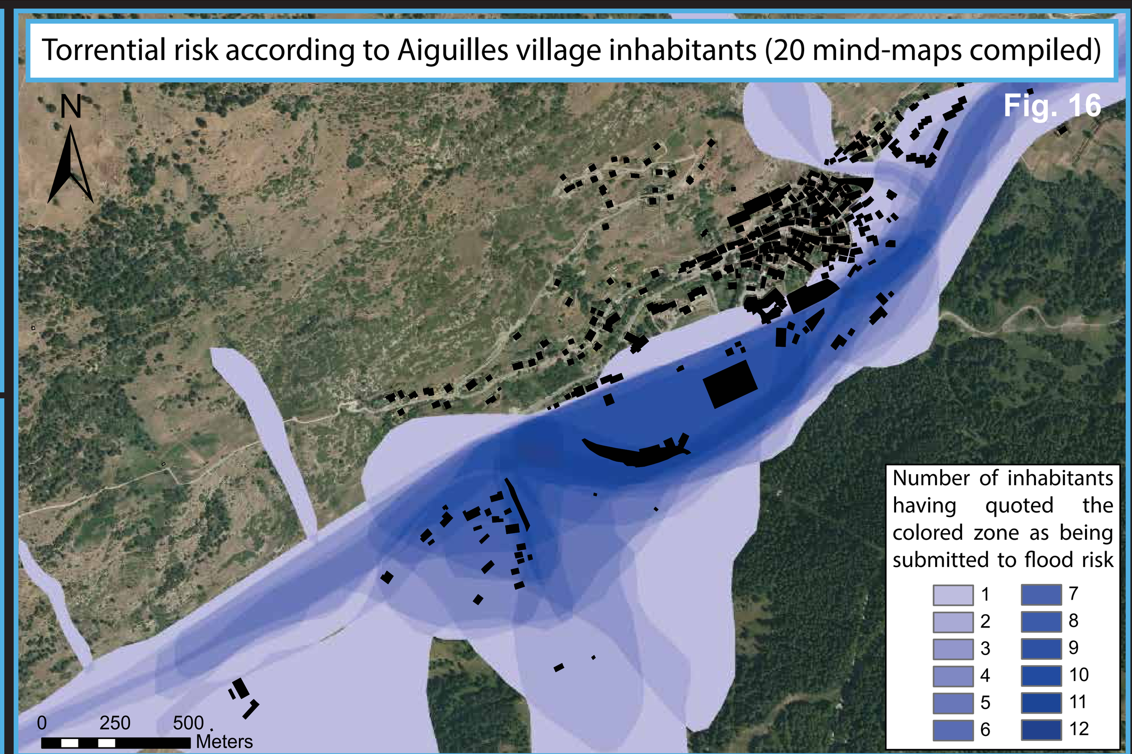
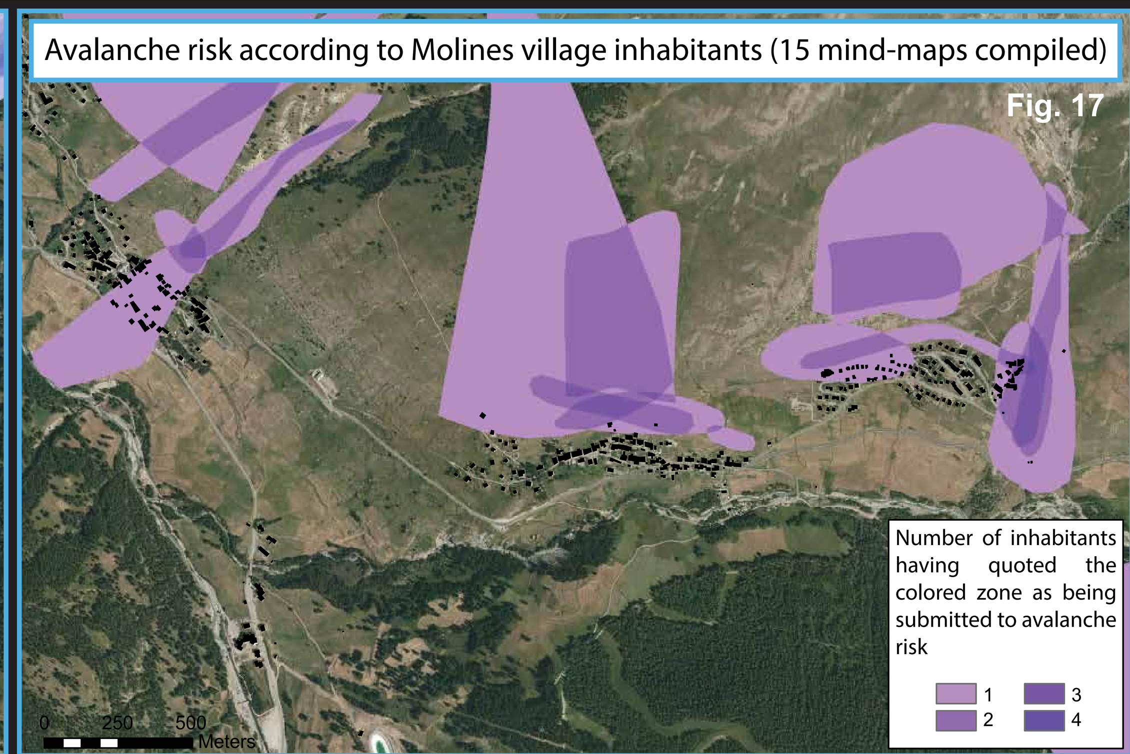


Fig. 15





5- Conclusion

This work remains part of a large study on risk in mountainous region that should lead to a **web demonstrator** intended for risk stakeholders. We expect that these first results on vulnerability will contribute to a better assessment of the global vulnerability of the upper Queyras region to hydrogeomorphic hazards. This work must help the development of **better land use** and could be used to help local authorities to improve and update their **Emergency Action Plan** or their **Prevention Plan**.
The next step of this work will be to try to elaborate a method combining all these maps to produce a **global risk map for mountain risks**.